Microbiological Quality and Food Safety of Plants Grown on ISS

Completed Technology Project (2013 - 2014)

Project Introduction

A challenge for growing fresh foods (vegetables) in space is demonstrating that they are safe for consumption according to NASA microbiological standards set for food. The goal of this project is to select and advance methods to enable real-time sampling, microbiological analysis, and sanitation of crops grown on the International Space Station (ISS). These methods would validate the microbiological quality of crops grown for consumption to ensure safe and palatable fresh foods. This will be achieved through the development / advancement of microbiological sample collection, rapid pathogen detection, and effective sanitation methods that are compatible with a microgravity environment.

This project aligns with current plans for deployment of a vegetable production unit on the International Space Station (Veggie) and the procurement and evaluation of platforms (RAZOR) at Kennedy Space Center for rapid microbial monitoring on ISS.

A 3-step approach is being used to evaluate and modify methods for analyzing fresh produce (fresh vegetables / fruits) that would be compatible with a microgravity environment. Candidate food crops are being grown in a controlled environment chamber for the following tests:

Food Safety Testing at KSC

Table of Contents

Organizational Responsibility

Responsible Mission Directorate:

Mission Support Directorate (MSD)

Lead Center / Facility:

Kennedy Space Center (KSC)

Responsible Program:

Center Independent Research & Development: KSC IRAD

Microbiological Quality and Food Safety of Plants Grown on ISS

Completed Technology Project (2013 - 2014)

1. Assessment of sampling procedures for surfaces of edible plant material to gather meaningful microbiological data. The three sample methods are surface swabbing, the use of adhesive tape to collect surface microbes and a blender method to remove microbes from plant tissue. The blender method is the conventional method for food sample processing. The other two methods have been tested as portable real-time methods to collect samples from the surfaces of meat as well as produce including tomato fruit and leafy greens
2. Analysis of samples using polymerase chain reaction (PCR), arabidopsis thaliana peroxidases (ATP) analysis, and culture based methods for enumeration as well as identification of target organisms with an emphasis on approaches that yield rapid results. The methods employed are all commercially available technologies. Our goal is to reduce detection time with the constraints of methodology that could practically be used on the ISS for sample analysis.
3. Comparison of sanitizing and disinfection procedures for the vegetables and plant growth unit surfaces, including methods developed and tested in the AES Habitat Demonstration Unit (HDU). The focus is on the development of a sanitizing wipe that can be used on plant growth systems such as Veggie as well as edible plant surfaces to reduce the microbial load. The sanitizer being used is a citric acid based food grade sanitizer (Pro-San®). This sanitizer has been tested previously and has been shown to be effective in the sanitization of edible vegetables.

Progress

A series of experiments has been completed using three different sampling procedures, swabbing, adhesive tape collection and sample blending for the recovery of bacteria from the surface of radish, tomato and lettuce. Data collected and analyzed to date show no significant difference using culture based detection methods between the adhesive tape and bag blender sample methods in the recovery of *Salmonella enterica* Typhimurium, a human associated food borne pathogen inoculated onto the surface of lettuce, tomato, and radish. The swab method recovery was significantly lower then the other two methods in the case of lettuce and radish. With the samples collected by these different sampling procedures we are comparing detection and quantification methods, specifically real-time quantitative polymerase chain reaction (q-PCR) using two platforms, the LightCycler® (Roche Diagnostics) and a rapid portable system, the RAZOR (Biofire, Salt Lake City, UT) with conventional culture based methods. For these tests we used *S. enterica* Typhimurium and *Eshcerichia coli* K12 inoculated onto the surface of red leaf lettuce and radish. We were able to detect *S. enterica* from 5/5 samples recovered from radish. This rapid method would eliminate the need for plating onto media or DNA extraction followed by real-time quantitative polymerase

Project Management

Program Manager:

Barbara L Brown

Project Manager:

Bryan G Onate

Principal Investigator:

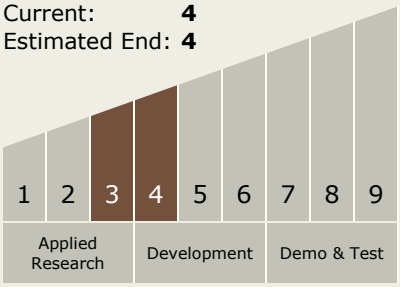
Raymond M Wheeler

Co-Investigators:

Anna Maria J Ruby
Gioia D Massa

Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**



Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
  - TX06.3 Human Health and Performance
    - TX06.3.5 Food Production, Processing, and Preservation

chain reaction (RT-qPCR) shortening detection and enumeration time from 12-48 hrs to approximately 3 hours.

Two concentrations of sanitizer-saturated wipes were tested to lower the microbial counts on radish, tomato and lettuce and plastic surfaces similar to the materials that comprise the Veggie plant growth system. The sanitizer was effective in lowering the bacterial count by 90- 99.9% on vegetable surfaces and up to 99.99% on plastic surfaces.

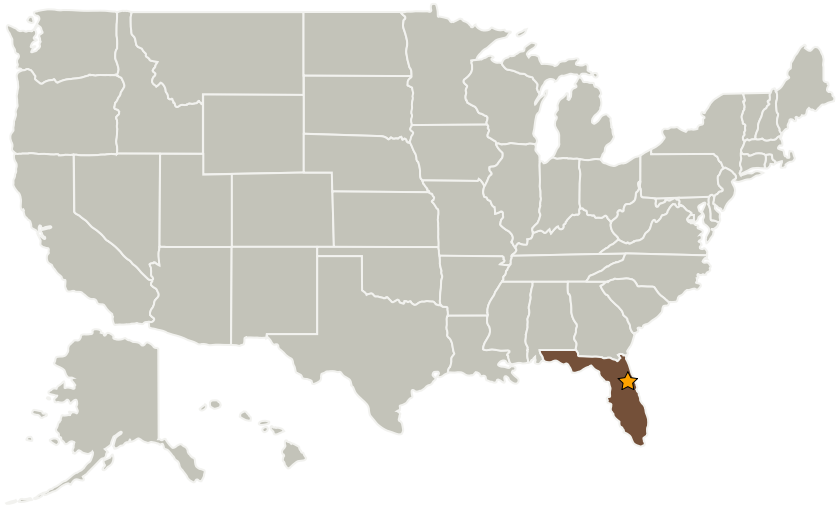
Anticipated Benefits

Methods specifically designed for quality assurance of fresh produce grown and consumed in space have yet to be defined. Currently, NASA astronauts cannot consume fresh foods grown in space. The need exists, as vegetable production units are being deployed on the the International Space Station (ISS). The Veggie plant growth unit, developed by Orbitec, was recently launched to the ISS and will be growing edible salad crops, and the Advanced Plant Habitat could also be used for future food production work.

These same capabilities developed for food production on the the International Space Station could be translated to future human exploration efforts, such as near-Earth object (NEO), Mars Transit, Lunar Surface, and Mars Surface missions.

Aerospace companies that have interests or aspirations for developing orbiting human habitats or transit vehicles could benefits from this research and technology development.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Kennedy Space Center(KSC)	Lead Organization	NASA Center	Kennedy Space Center, Florida

Microbiological Quality and Food Safety of Plants Grown on ISS

Completed Technology Project (2013 - 2014)

Co-Funding Partners	Type	Location
LuminUltra Technologies Ltd.	Industry	Fredericton, Outside the United States, Canada
Microcide, Inc.	Industry Small Disadvantaged Business (SDB), Women-Owned Small Business (WOSB)	Troy, Michigan

Primary U.S. Work Locations
Florida

Images

Food Safety Testing at KSC
Food Safety Testing at KSC
(https://techport.nasa.gov/image/3038)

Radish and Lettuce Microbiological Quality and Food Safety
Radish and Lettuce Microbiological Quality and Food Safety
(https://techport.nasa.gov/image/3036)

Red Leaf Lettuce for Food Safety Testing
Red Leaf Lettuce for Food Safety Testing
(https://techport.nasa.gov/image/3037)